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Logging Damage to Advance Regeneration on an Arizona Mixed Conifer Watershed

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Gerald J. Gottfried and John R. Jones

Abstract

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Old-growth southwestern mixed conifer stands commonly have considerable advance regeneration, but one-cut overstory removal, with subsequent slash piling, typically has destroyed most of it. Furthermore, except where aspen suckers abundantly, subsequent regeneration is usually very slow. This study examines damage to advance regeneration where special care was taken to avoid damage. With the selection method, 50 percent was destroyed, and in a one-cut overstory removal, 65 percent. The overstory removal area was left seriously understocked. Logging modifications are recommended to further reduce damage.

Keywords: Advance regeneration, logging damage, mixed conifer forests.

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Contents

	Page
Introduction	1
The Study Area	1
Logging Control	2
Slash Treatment	3
Study Methods	3
Results	4
Overstory	4
Advance Regeneration	4
Photo Comparisons	4
Data Comparisons	18
Trees per Acre	18
Stocking Level Distribution	18
Discussion	18
Overstory Removal	18
Selection Method	19
Recommendations to Reduce Damage	19
Conclusions	20
Literature Cited	20
Common and Scientific Names of Plants Mentioned	20

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INTRODUCTION

Southwestern mixed conifer stands occupy about 2.5 million acres in Arizona, New Mexico, and southern Colorado. They often have considerable advance regeneration—young trees that have already survived the critical first years and passed the period of very slow early growth. If enough of these small trees survive logging operations, a harvested area is already restocked, and the next rotation is significantly shortened. Where logging removes large timber volumes, however, much of the advance regeneration is typically destroyed.

Saving this advance regeneration is important in the Southwest, where natural regeneration of openings is often slow (Jones 1967) and planting is costly. In this case study we found that, even when special care is taken, conventional logging reduced the abundance and distribution of advance regeneration below acceptable stocking levels.

THE STUDY AREA

The study area is a gaged watershed on the Apache-Sitgreaves National Forest in east-central Arizona, drained by the East Fork of Willow Creek. Elevations range from 8,800 to 9,300 feet. Slopes average 20 percent. Soils are a stony silty clay loam, and do not erode readily. Parent material is basalt.

Average annual precipitation is 29.6 inches. Winters are normally mild, but snow cover commonly persists from November into April. May and June have many windy days and are almost always very dry. In July and August, rain falls on about 50 percent of the days, mostly as daytime thundershowers, some of them heavy. September and October often are dry but have occasional high water-yielding storms.

The heavy soils, abundant snow, and warm days in winter make roads and soils susceptible to damage from trucks and tractors, thus restricting winter logging. Skidding and hauling are occasionally halted in summer and fall to avoid damage to saturated slopes and roads. Extreme fire danger sometimes slows logging in May and June. Trees with decayed butts, and occasional strong winds, sometimes frustrate attempts at directional felling.

The watershed covers 492 acres, 468 of which were virgin forest prior to the study. The other 24 acres are a narrow meadow along the creek. All forested areas were stocked with at least 25 square feet of basal area in trees 7 inches in diameter breast high (d.b.h.) and larger, in 1970. Average timber volume was 23,800 board-feet per acre. Many trees, especially Douglas-fir, were more than 30 inches d.b.h. The species, in descending order of volume, were Douglas-fir, Engelmann spruce, ponderosa pine, aspen, white fir, southwestern white pine, blue spruce, and corkbark fir.[2] Composition and structure were variable. All of the species, with the exception of blue spruce, occurred widely over the watershed. Some species were particularly abundant in certain areas: 27 acres were dominated by aspen with a partial understory of conifers; 8 acres were dominated by Engelmann spruce.

There were some single-storied patches, but even these had some advance regeneration. Most of the stands had two or more stories. Patches and thickets of saplings were common. Much of the forest was a small-patch mosaic of different structures.

Our evaluation of logging damage to advance regeneration is part of a larger study on Willow Creek. The overall objective is to test the effects of a combination of cutting methods, based on stand conditions, on the timber, water, and wildlife resources. Two different treatments were applied: the selection method and overstory removal (fig. 1). On the 114-acre area where the selection method was

[2] *Common and scientific names of species mentioned are listed on page 20.*

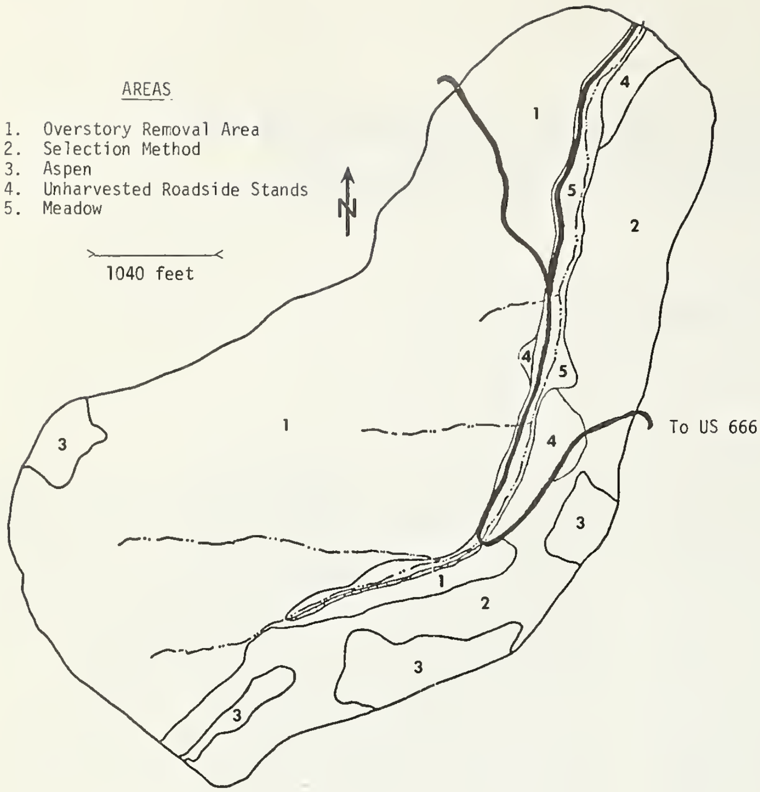

Figure 1.—

The Willow Creek East Fork watershed is located 25 miles south of Alpine, Arizona.

used, cutting was light to moderate, removing individual trees and small groups, with an emphasis on salvaging defective veterans.

Marking on the 302-acre overstory removal area was based on a 10-inch diameter limit. Some trees larger than 10 inches were left, especially near roads to reduce visual impact. Occasional large defective veterans were left, primarily for use by birds. Where pole-sized trees were numerous, some as small as 6 inches d.b.h. were marked for pulpwood. In addition, 8 acres of single-storied Engelmann spruce were clearcut. Aspen was not cut, because there was little market for it. Seventeen acres of conifers along the meadow were uncut.

Table 1 summarizes the changes in overstory conditions for both treatment areas. Stocking after treatment on the overstory removal area was highly variable. Some parts were nearly bare, while some aspen patches were undisturbed.

Logging Control

Before logging, the timber sale area was examined jointly by the Black River District Ranger and staff assistants, representatives of Southwest Forest Industries (the timber purchaser), and of Holliday Logging Company (the logging operator). Also present were the Forest Supervisor and staff assistants, representatives of the Regional Forester, and personnel of the Rocky Mountain Forest and Range Experiment Station. The purposes and problems of the operation were discussed thoroughly, with emphasis on the need for special care to avoid damage to the advance regeneration.

Table 1.--Overstory conditions for areas treated by selection method and by overstory removal (based on a 25 basal-area-factor cruise of trees 7 inches d.b.h. and larger)

Treatment	Area treated	Per-acre conditions		
		Trees	Basal area	Gross volume[1]
	Acres	*No.*	*Ft²*	*Bd.ft.*
SELECTION METHOD:	114			
Before logging		230.40	197.30	23,617
After logging		152.38	135.14	16,483
OVERSTORY REMOVAL:	302			
Before logging		146.18	178.81	26,564
After logging		43.71	29.24	3,017
		Percent reduction		
SELECTION METHOD		34	32	30
OVERSTORY REMOVAL		70	84	89

[1]Scribner Decimal C.

Supervision and contractor cooperation were good. The sawtimber and pulpwood operations were separate, though overlapping in time. A sale administrator was assigned to each operation to provide close supervision. Both sale administrators had a good working relationship with the logging operator and his crews. Whenever they were in the vicinity, Experiment Station personnel visited the area and examined operations along with the operator and sale administrators. Southwest Forest Industry foresters were often on the area. It was clear that sawyers were making an effort to avoid dropping trees in concentrations of advance regeneration, or where skidding damage would be severe. Sometimes, however, the two were mutually exclusive, and the sawyer had to choose between either substantial felling damage or substantial skidding damage.

The sawtimber was ground skidded by D6 and D7 crawler tractors. Small rubber-tired skidders were used to remove much of the pulpwood. Hot logging greatly reduced the area denuded for decking logs.

Slash Treatment

Slash piling and burning has often virtually eliminated the advance regeneration which survived logging. At Willow Creek, slash was lopped and left in place over most of the area to avoid such damage. Slash was skidded and piled on the 8 acres of spruce clearcutting, however, to avoid a possible buildup of spruce beetles. In addition, a 3-chain-wide (198-feet) fuel break was constructed by the Forest Service around the watershed perimeter. Slash within 1 chain (66 feet) of the main road also was piled. Only dead fuel was piled in the fuel break. Bulldozers were kept out of concentrations of advance regeneration during construction. If slash lay where machine piling would do appreciable damage, it was simply lopped in place or, where abundant, lopped and hand piled. Piles were scheduled for burning in 1974.

STUDY METHODS

Advance regeneration was compared before and after logging. To reduce error, the same sample strips were used for both examinations.

Marked timber survey points had previously been established on 12 lines according to a multiple-random start design. Transects through the survey points were used as the basis for sampling advance regeneration. Each of the 12 transects was the center line of a narrow sample strip. A 30-inch steel stake was driven at each survey point, usually to within 3 or 4 inches of the ground surface. Each stake was referenced to one or more (usually two) witness trees, which were tagged below stump height.

Advance regeneration was divided into five classes so we could ascertain the relationship between size and susceptibility to damage:

Established small seedlings	3.0-11.9 inches tall
Large seedlings	1.0-4.5 feet tall
Small saplings	0.1-1.9 inches d.b.h.
Large saplings	2.0-3.9 inches d.b.h.
Small poles	4.0-6.9 inches d.b.h.

Small seedlings were sampled on circular 4-milacre plots. The plot centers were located 15 feet magnetic south of the stakes, roughly at right angles to the transects, to avoid damaging sample seedlings while we conducted other activities. There were 37 plots in the selection area and 117 in the overstory removal area. Total small seedlings were not counted; they were recorded by species as zero, one, two, or more than two per plot.

Large seedlings and small saplings were counted along all 12 transects. Strips were 6.6 feet wide, with a total sample area of 3.33 acres in the overstory removal area and 0.96 acre in the selection area. Large saplings and small poles were counted along six alternate transects on strips 16.5 feet wide, with a total area of 4.05 acres in the overstory removal area and 1.20 acres in the selection area.

Advance regeneration was rated as growing stock if it would reasonably produce a merchantable product at some time. Trees not considered growing stock were primarily saplings and seedlings with severe dwarf mistletoe or with dead tops; the latter were usually severely suppressed.

During the postlogging examination only, growing stock (except for small seedlings) was further classed as good or fair. Good growing stock was that which the examiner judged to be at least fairly vigorous, free of dwarf mistletoe, and of good form. Fair growing stock had some defect but had the potential to maintain itself in the stand and eventually produce at least pulpwood. Good growing stock is more meaningful from the viewpoint of timber production. For cover and forest scenery after logging, however, total growing stock is important.

Forty-three photos were taken from transect stakes both before and after logging. The camera was aimed along or at estimated angles from the transects. The views were selected before logging to show the spectrum of stand conditions. An edge or corner of each view was referenced before logging to some distinctive feature, such as the base of a large tree, so that the same view could be rephotographed after logging. In a few instances the after photo only approximates the view of the original because the reference feature was lost.

RESULTS

Overstory

Changes in the number of trees, basal area, and volume were more severe in the overstory removal area (fig. 2) than in the selection area (table 1). After logging, 95 percent of the timber inventory points in the selection area were stocked with one or more trees 7 inches d.b.h. or larger as defined by a 25 basal area factor gage. In contrast, 53 percent of the inventory points were stocked in the overstory removal area, only 35 percent by conifers.

Advance Regeneration

Before logging, the two treatment areas were similarly stocked with advance regeneration (table 2). Logging damage was considerably greater on the overstory removal area than on the selection area.

Photo Comparisons

The data can be better appreciated after examining the "before and after" photographs (figs. 3-15). The photos labeled *A* were taken before logging; those labeled *B* were taken after logging. The situations illustrated are described in the captions. Results of the selection method did not vary greatly; figures 3-6 were sufficient to show most of the range of before-and-after contrasts. Figures 7-13 show the results of overstory removal. Figures 14 and 15 show the results of logging in the aspen patches.

Table 2.--Total advance regeneration per acre,[1] by treatment, before and after logging

Treatment and size class	Before logging	After logging	Lost	Survivors rated 'good'
	Stems/acre		*Percent*	
SELECTION METHOD:				
Large seedlings	404.17	187.50	54	54
Small saplings	96.88	51.04	47	61
Large saplings	61.67	35.83	42	54
Small poles	71.67	42.50	41	55
Total	634.39	316.87	50	55
OVERSTORY REMOVAL:				
Large seedlings	446.25	148.65	67	43
Small saplings	110.81	37.24	66	37
Large saplings	69.63	25.68	63	45
Small poles	79.26	35.80	55	48
Total	705.95	247.37	65	43

[1]Conifers and aspen; excludes small seedlings.

Figure 2.—A broad view of the overstory removal area.

A. BEFORE

Figure 3.—Selection method. Exterior view, relatively little disturbance.

B. AFTER

A. BEFORE

Figure 4.—Selection method. Interior view, relatively little disturbance.

B. AFTER

A. BEFORE

Figure 5.—Selection method. Area moderately disturbed.

B. AFTER

A. BEFORE

Figure 6.—Selection method. Area considerably disturbed.

B. AFTER

A. BEFORE

Figure 7.—Overstory removal. Some areas had relatively few unmerchantable trees. Overstory removal and accompanying disturbance constitute clearcutting. (The midground trees were purposely left along the meadow edge.)

B. AFTER

A. BEFORE

Figure 8.—Overstory removal. Considerable areas with advance regeneration had heavy volumes of large, old trees whose removal largely destroyed the advance regeneration. The result was essentially a clearcutting.

B. AFTER

A. BEFORE

Figure 9.—Overstory removal. Some areas had abundant regeneration and substantial but not heavy merchantable volumes, as in the foreground and midground. Logging damage commonly left such patches partially stocked. (The background ridge is in the selection area.)

B. AFTER

A. BEFORE

Figure 10.—Overstory removal. In some instances where advance regeneration was fairly abundant, logging damage seemed excessive.

B. AFTER

A. BEFORE

Figure 11.—Log landing. Little or no advance regeneration survives on or around log landings. Landings usually occupy more ground where cutting is heavy, as in overstory removal. Hot logging on this sale minimized landing area. (The background ridge is in the selection area.)

B. AFTER

A. BEFORE

Figure 12.—Overstory removal. Numerous patches had low merchantable volume and abundant advance regeneration. Careful routing of skidding traffic left most of these moderately to well stocked.

B. AFTER

A. BEFORE

Figure 13.—Overstory removal. Some areas were essentially two-storied with a sawtimber overstory and many subordinate small poles. Removal of the overstory resulted in heavy blowdown of residual poles.

B. AFTER

A. BEFORE

Figure 14.—Aspen patch. Numerous patches within the overstory removal area were dominated by aspen. Removal of associated conifers did not constitute overstory removal, nor was the advance regeneration seriously damaged. Exterior view.

B. AFTER

A. BEFORE

Figure 15.—Interior view of a patch dominated by aspen.

B. AFTER

Data Comparisons

Trees per Acre

Comparative density data, before and after logging, are given for both treatment areas in table 2. Logging activities on the overstory removal area, destroyed 65 percent of the advance regeneration (if small seedlings are ignored). Only 43 percent of the survivors were rated good. Losses were also heavy on the selection area—50 percent—despite much lighter timber removal. Of the survivors, 55 percent were rated good.

In both treatment areas, the data show a consistent trend of decreasing losses with increasing size from large seedlings to small poles. Larger regeneration is easier for fallers and tractor operators to see, and both workers in deciding where to drop a tree or drive a tractor, are more likely to spare a pole or large sapling than a seedling.

We do not know the exact percentages of small seedlings lost because our inventory method did not give full counts on some plots. Full counts were more common in the posttreatment inventory. On the selection area, the postlogging tally of 257 trees per acre was 60 percent less than the prelogging count, and on the overstory removal area, the postlogging tally of 122 trees per acre was 80 percent less. Actual losses were greater than these percentages.

Stocking Level Distribution

The **distribution** of advance regeneration within the stand is as important as the **number** of trees. It is conceivable that we could denude half the area, but still only lose a moderate number of trees.

Because the original sampling design did not allow for evaluation of stocking level distribution we made a supplemental survey in 1974. Four-milacre plots were offset at about 1-chain intervals along the inventory lines. There were 116 plots in the selection area and 350 plots in the overstory removal area. Trees of all sizes that were present in 1971 were tallied, as were new aspen sprouts. Approximately 4 percent of the overstory-removal plots contained prelogging aspen.

The results are indicated below. Two levels of stocking are shown because of the uncertainty of what constitutes optimum stocking in Arizona mixed conifer stands.

	Selection area	Overstory removal area
Percent stocked with at least:		
1 conifer	47	36
2 conifers	32	19
Percent stocked with at least:		
1 aspen	28	40
2 aspens	20	32
Percent stocked only with aspen	14	23
Percent stocked with at least 1 tree		
in 1972	47	37
in 1974	60	59
Percent stocked with at least 2 trees		
in 1972	32	21
in 1974	47	48

DISCUSSION

Overstory Removal

Heavy logging damage to advance regeneration, combined with removal of most of the overstory, left the overstory removal area understocked. Furthermore, many residual poles and suddenly exposed immature sawtimber trees blew down, mostly after the postlogging survey. Their loss, not reflected in the regeneration data and only partly in the photographs, leaves the area still more poorly stocked. Salvaging the blowdowns will cause additional logging damage.

Establishment of new seedlings is usually slow on exposed sites, especially in the absence of abundant seed. Even under highly favorable conditions, it takes a decade or more for most newly germinated mixed conifer seedlings to reach breast height (Jones 1971). Therefore, the poor stocking of advance regeneration in general, and especially the loss of numerous saplings and poles which were beyond the slow-growing seedling stage, will seriously delay production of coniferous timber on the overstory removal area.

Since the survey, aspen suckering on the overstory removal area has been widespread, fairly abundant, and of acceptable vigor. This has greatly improved overall stocking, which now approaches adequate on most of the overstory removal area. Overstory removal has, in this case, converted a forest dominated by old conifers to a young forest pre-

dominatly of aspen suckers but with a modest representation of conifers. Some of these conifers, primarily those which are already saplings and poles, will share the future canopy with the fast-growing young aspens and provide a future seed source. Most of the smaller advance conifer regeneration will be outgrown and return to understory status.

While the market for aspen timber has been very limited in the Southwest, aspen has become salable as pulpwood here since this operation. It is likely that aspen fiber will be fully marketable within a few decades. Thus the value of timber produced by the predominantly aspen forest may match in value that which would have been produced had the overstory removal area been treated instead by the selection method or a three- or four-cut shelterwood that maintained coniferous dominance. The simplicities of aspen regeneration should be attractive to forest managers.

The consequences of this one-cut overstory removal and the accompanying type conversion influence values other than timber production. Conversion to young aspen forest has advantages for deer and elk management.[3] Also, a fair amount of aspen forest in locales widely dominated by conifers seems esthetically desirable, especially when the aspen stands include scattered coniferous trees and groves. It will be decades, however, before the overstory removal area will be as attractive to most people as the adjacent selection forest.

The treatments should increase water yields from the watershed. Based on the experiments on Workman Creek, Arizona,[4] most of this increase would come from the overstory removal area. Young aspen stands may bring water yields back down to prelogging levels much sooner than if the area had regenerated gradually with only slow-growing coniferous seedlings. Limited study suggests, however, that yields will probably remain above prelogging levels for more than 3 years, despite vigorous growth by the young aspen (Johnston et al., 1969). Continued gaging of streamflows from this and the adjacent uncut watershed will provide information on the duration of increased water yields.

[3] *Patton, David R., and John R. Jones. 1975. Management of aspen for wildlife in the Southwest. (Unpublished manuscript on file with Project 1702, Forest Hydrology Laboratory, Rocky Mountain Forest and Range Experiment Station, Tempe, Arizona).*

[4] *Rich, Lowell R., and Gerald J. Gottfried. 1975. Water yields resulting from treatment on the Workman Creek experimental watersheds of Central Arizona. (Unpublished manuscript on file with Project 1612, Forest Hydrology Laboratory, Rocky Mountain Forest and Range Experiment Station, Tempe, Arizona).*

Selection Method

The selection forest remains satisfactorily stocked with a combination of residual overstory trees and advance regeneration. Much advance regeneration was destroyed, however, especially seedlings and small saplings, despite efforts by the loggers to avoid damage.

The removals and disturbance would have been much the same had this been the first of three shelterwood cuts in the same stand. In most virgin mixed conifer forests in the Southwest, the first cut must be light to moderate in either system, to develop windfirmness in the residual stand. In the shelterwood system, however, the entire overstory would be removed in installments covering a period of perhaps 20 years, and the repeated loss of so much regeneration might be more serious.

RECOMMENDATIONS TO REDUCE DAMAGE

Logging damage can be reduced by three changes in logging procedures:

1. **Marking and clearing skid trails.**—Skid trails were made as needed by the skidding tractors. Windfalls, fallen snags, and other unmerchantable down material, commonly in long lengths, were pushed out of the way or detoured. Detours slowed the work, disturbed excessive area, and damaged more regeneration. Pushing the down material out of the way with the tractor blade also did considerable damage to advance regeneration. Much of that damage could be avoided by marking skid trails and having a swamper saw out sections of the down material to help clear the trail. Bulldozing these short sections aside would do much less damage. Trees along marked skid trails can be felled at angles to minimize skidding damage.

2. **Careful winching.**—More winching would be necessary if tractors were restricted to marked and pre-cleared trails. Logs being winched to a tractor sometimes catch on down material and drag it sideways, destroying and damaging regeneration. A swamper or the choker setter, using a light chain saw, could sever or saw out sections of material that lay in the way, making winching easier and reducing damage to regeneration.

3. **Varying log lengths.**—Logs sometimes fall in situations where they are difficult to remove, especially by winching, if they are of large diameter and a standard 32 feet long. Tractors must sometimes circle around through regeneration to push such heavy logs into positions from which they may be pulled. This commonly requires pushing or rolling

the log sideways, regardless of damage to seedlings and saplings. If sawyers are trained to watch for these situations, they could cut shorter logs when necessary. It is sometimes necessary to fall a tree at an unfavorable angle to the skid trail, for example, to avoid lodging, or felling a treetop into regeneration. Logs being winched or otherwise pulled onto the trail are then dragged through an arc sideways, often destroying saplings and seedlings and damaging poles and larger trees. If sawyers are trained to recognize these situations, they could cut shorter logs to reduce the arc of destruction.

Putting these suggestions into effect would involve changes in sale preparation and administration, and possibly modification of standard contracts. They probably would be considerably more effective if brief training sessions were held for sawyers, skidders, swampers, and choker setters. It might even be specified that men without such training could not work on timber sales where such methods are required.

CONCLUSIONS

One-cut removal of a mixed conifer overstory destroyed about two-thirds of the advance regeneration and left the area seriously understocked, despite substantial efforts to avoid damage. This harvesting system should not be used where advanced regeneration is to provide the subsequent stand. Even with care and improved logging techniques, adequate stocking of advance coniferous regeneration seems unlikely to survive one-cut overstory removal in stands with large merchantable volumes. The result approaches clearcutting. One-cut overstory removal can only be recommended where clearcutting is acceptable—perhaps to increase water yields, or improve forage for deer and elk.

The selection method, and the first removals under a multiple-cut shelterwood system, do less damage, but considerable advance regeneration is lost nonetheless. Minor changes in harvesting methods could reduce this damage, and make timber production more fully compatible with other forest management goals.

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COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED

Engelmann spruce	*Picea engelmannii* Parry
Blue spruce	*Picea pungens* Engelm.
Rocky Mountain Douglas-fir	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
White fir	*Abies concolor* (Gord. and Glend.) Lindl.
Corkbark fir	*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm.
Ponderosa pine	*Pinus ponderosa* Laws.
Southwestern white pine	*Pinus strobiformis* Engelm.
Quaking aspen	*Populus tremuloides* Michx.

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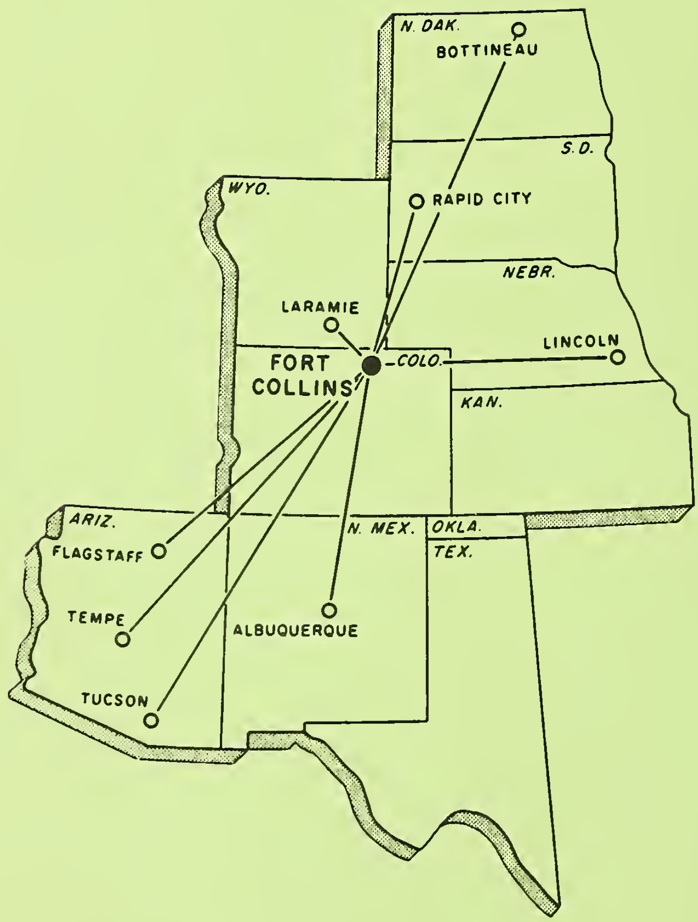
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